Convective Characteristics in Hurricanes Florence (2018), Dorian (2019), and Laura (2020)

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Hurricane Florence (2018) - Background

- Formed in eastern Atlantic Ocean on 30 August 2018
- Rapidly intensified twice, once about 48 hours prior to landfall
- Made landfall in North Carolina over two weeks after forming

Hurricane Dorian (2019) - Background

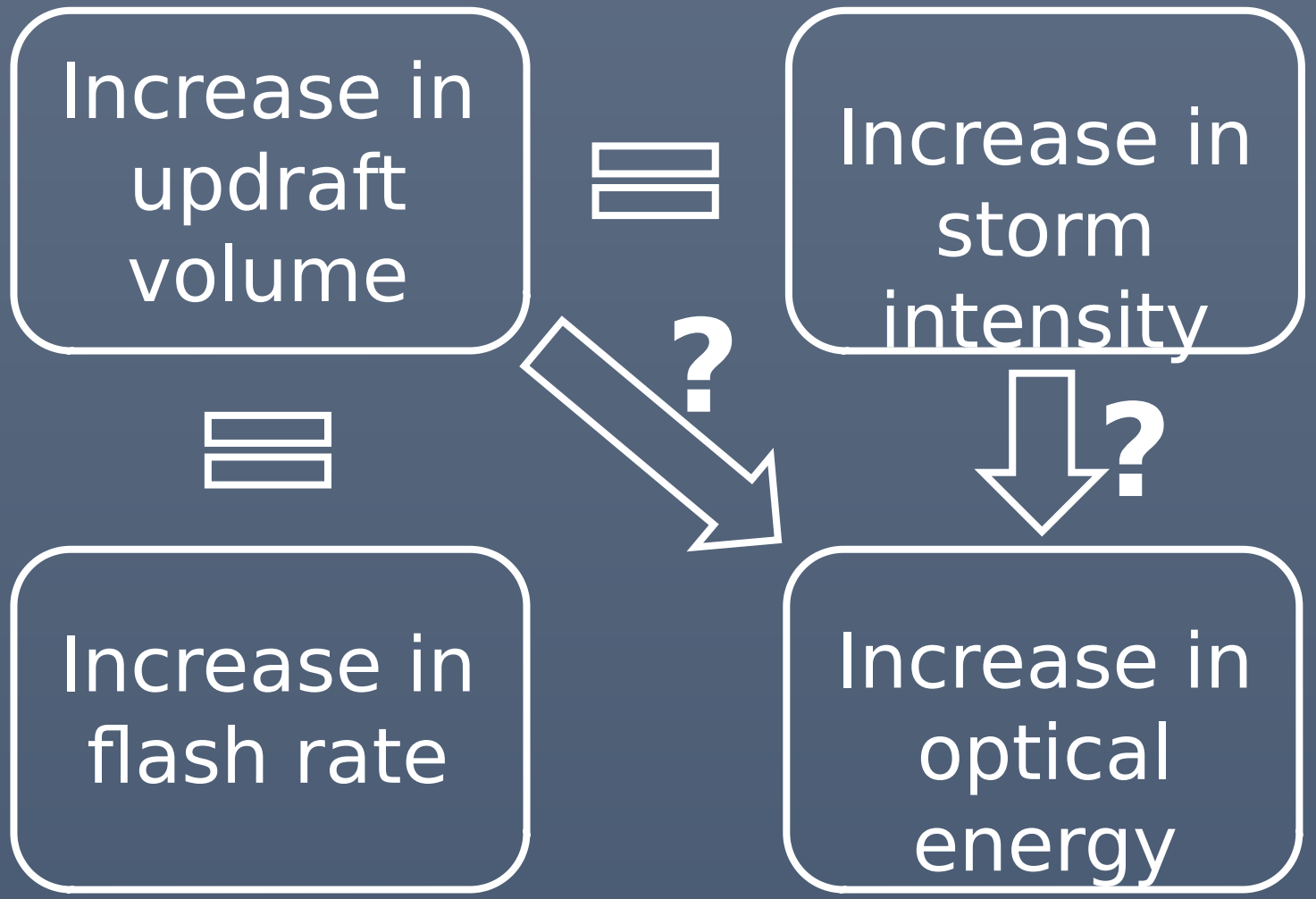
- Formed on 24 August 2019 in the western Atlantic Ocean
- Rapidly intensified just prior to landfall in Abacos
- Became nearly stationary just off the coast of southeast Florida for about 36 hours as a major hurricane
  - Lots of lightning during this time

Hurricane Laura (2020) - Background

- Formed in the Gulf of Mexico on 20 August 2020
- Rapidly intensified just prior to landfall on 27 August
- Made its final landfall as a category 4 hurricane (130 knots) in southeast

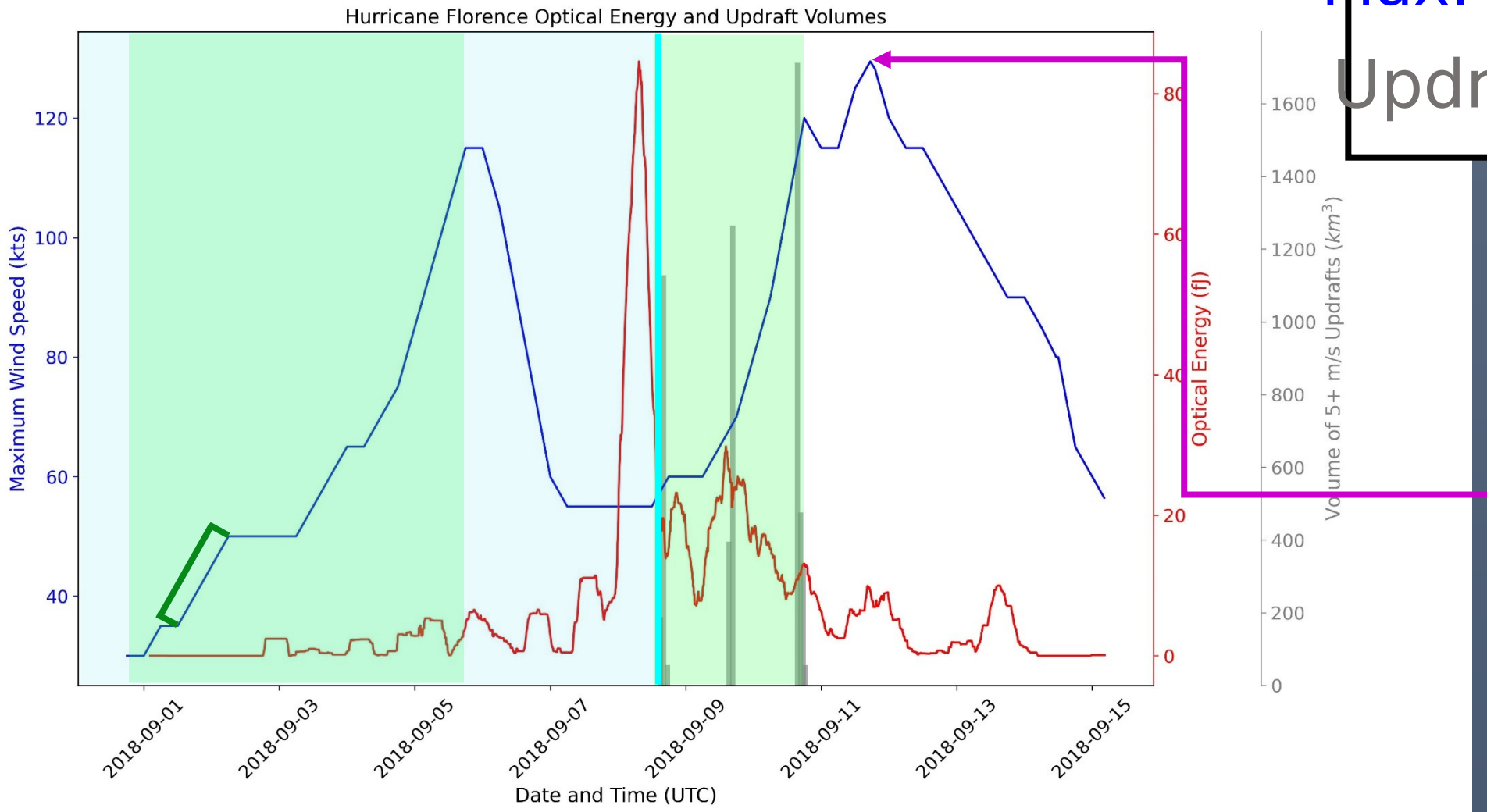
Motivation

- Inner eyewall lightning outbreaks have had conflicting results when studying changes in flash count and TC intensity
- TC updraft volumes have been studied as an indicator of storm intensity[1, 2, 3]
- Updraft volumes have been linked to an increase in flash rate but not yet optical energy[2]
- GLM allows for lightning to be monitored near-constantly over the oceans



- **Can GLM optical energy in the innermost 100 kilometers be used as a tool for forecasting imminent TC intensity changes?**

Results – Florence Optical Energy



Optical Energy

Max. Wind Speed

Updraft Volume

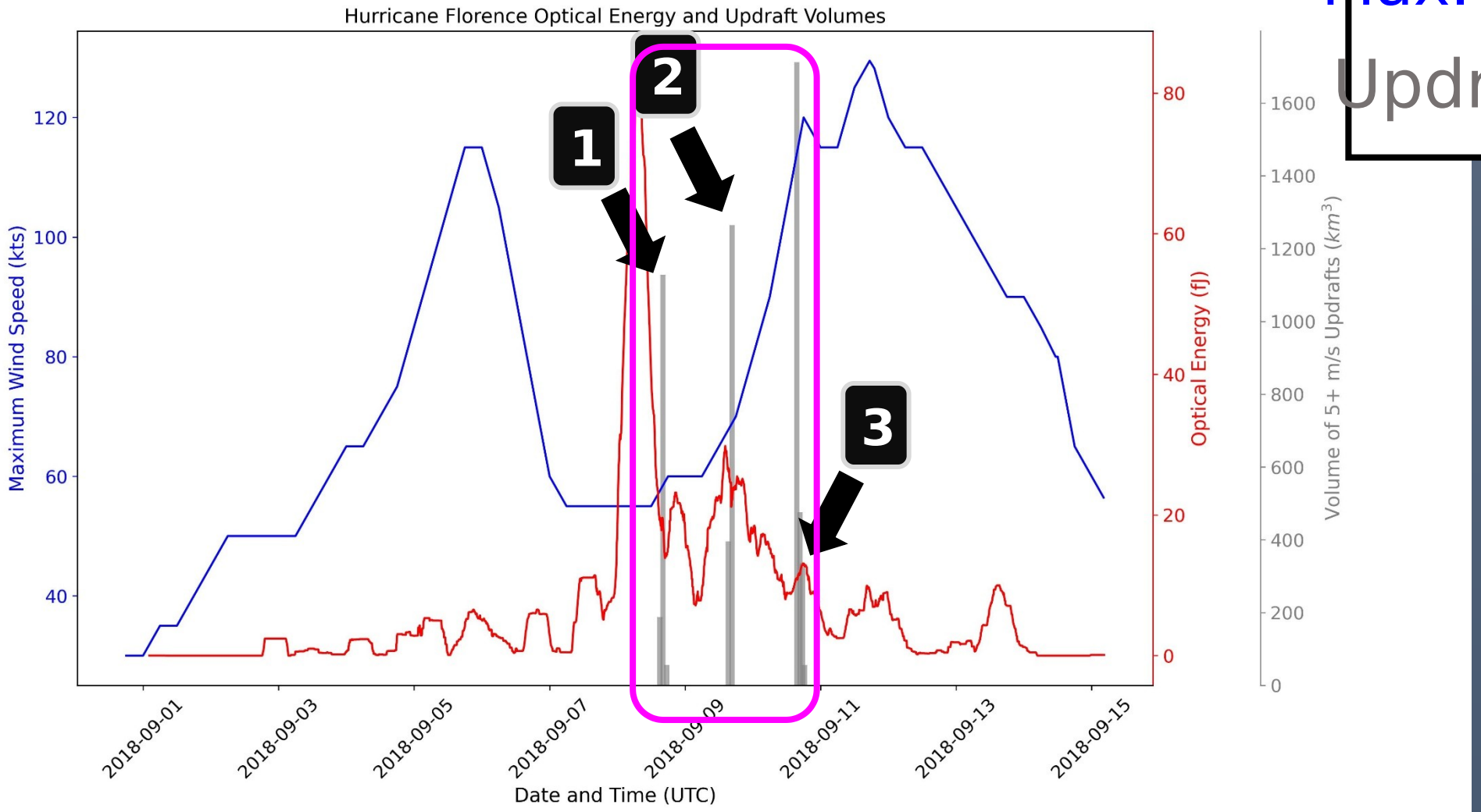
Maximum intensity

Results – Florence Optical Energy

Optical Energy

Max. Wind Speed

Updraft Volume

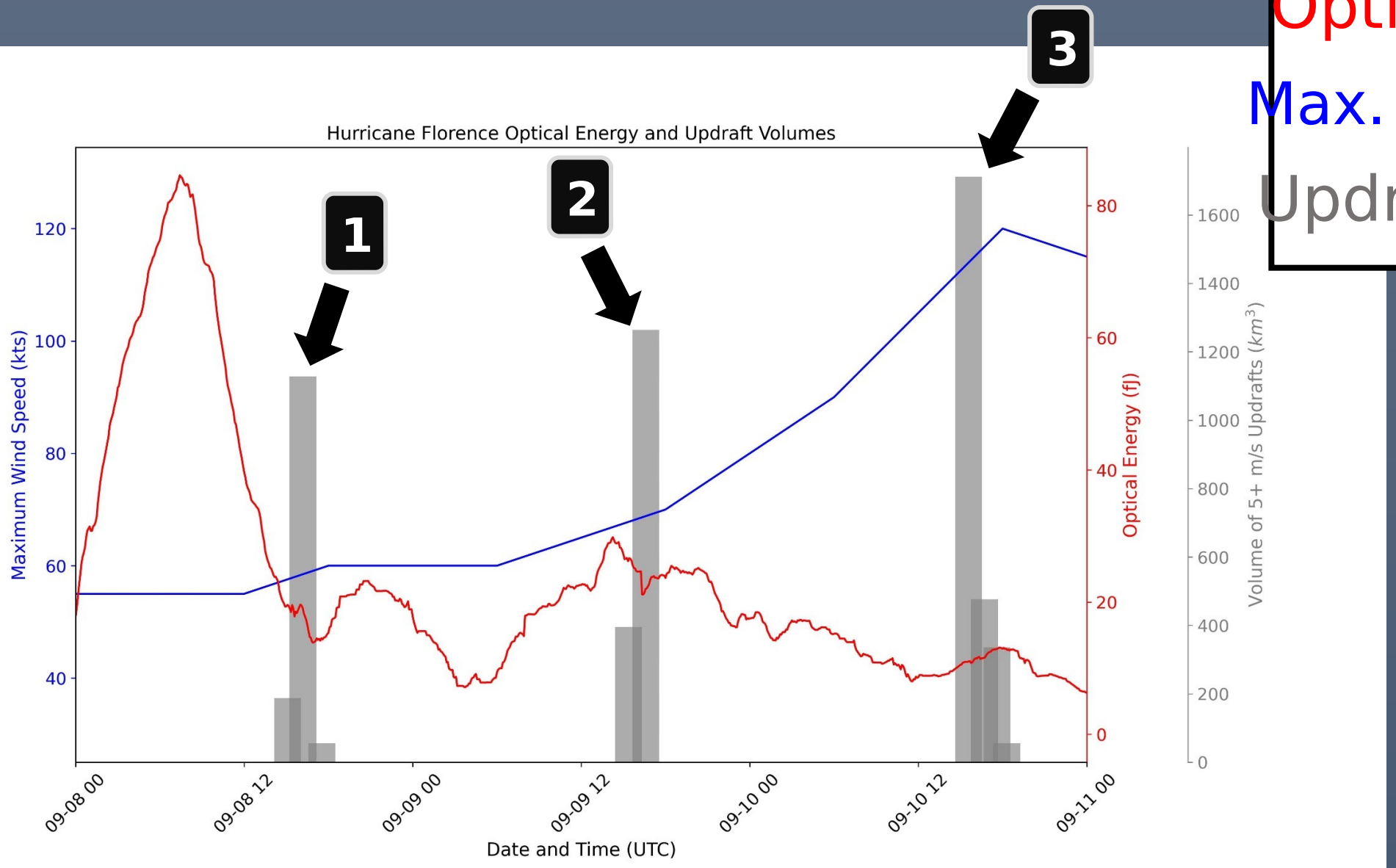


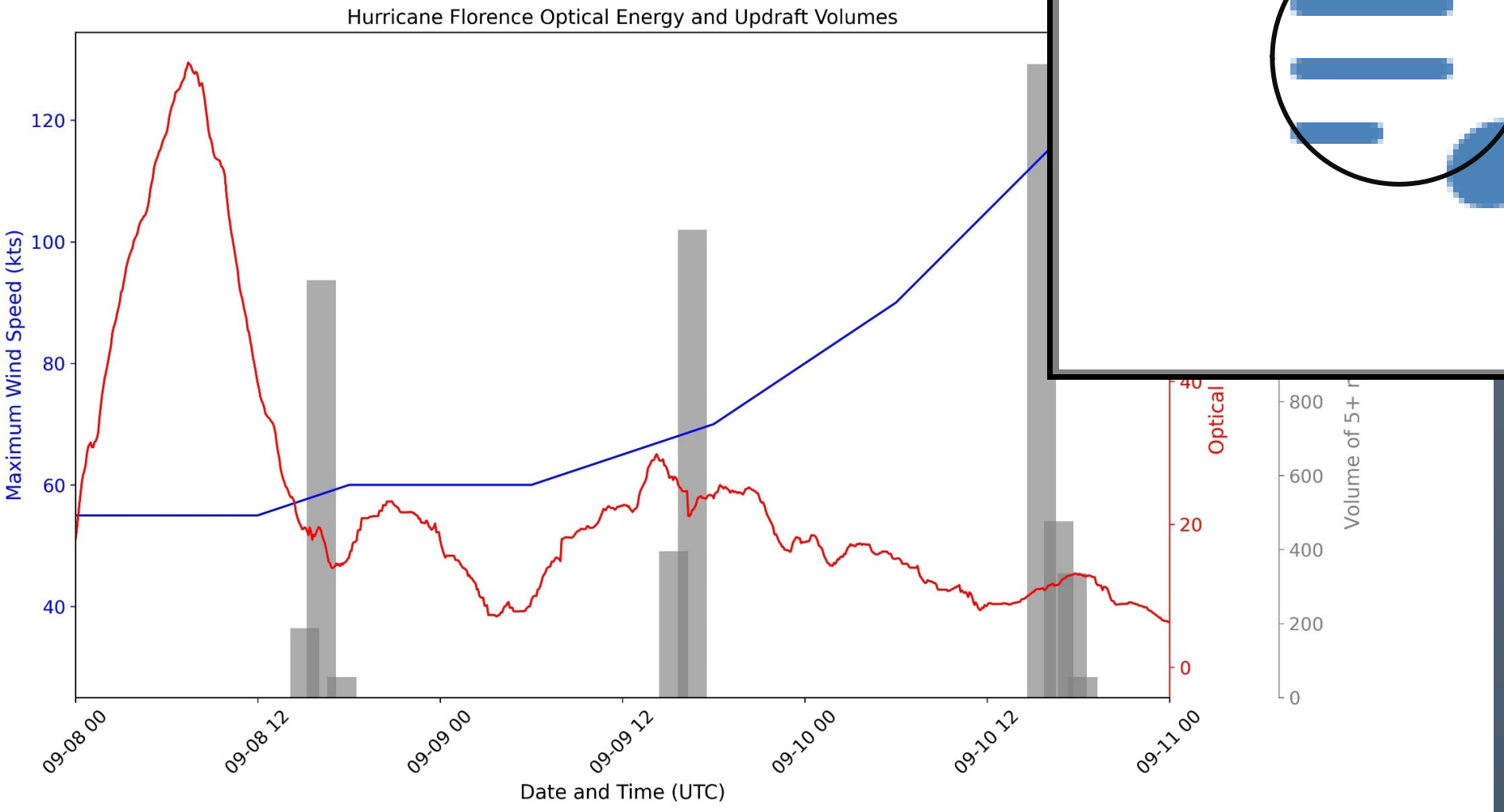
Results – Florence Optical Energy

Optical Energy

Max. Wind Speed

Updraft Volume



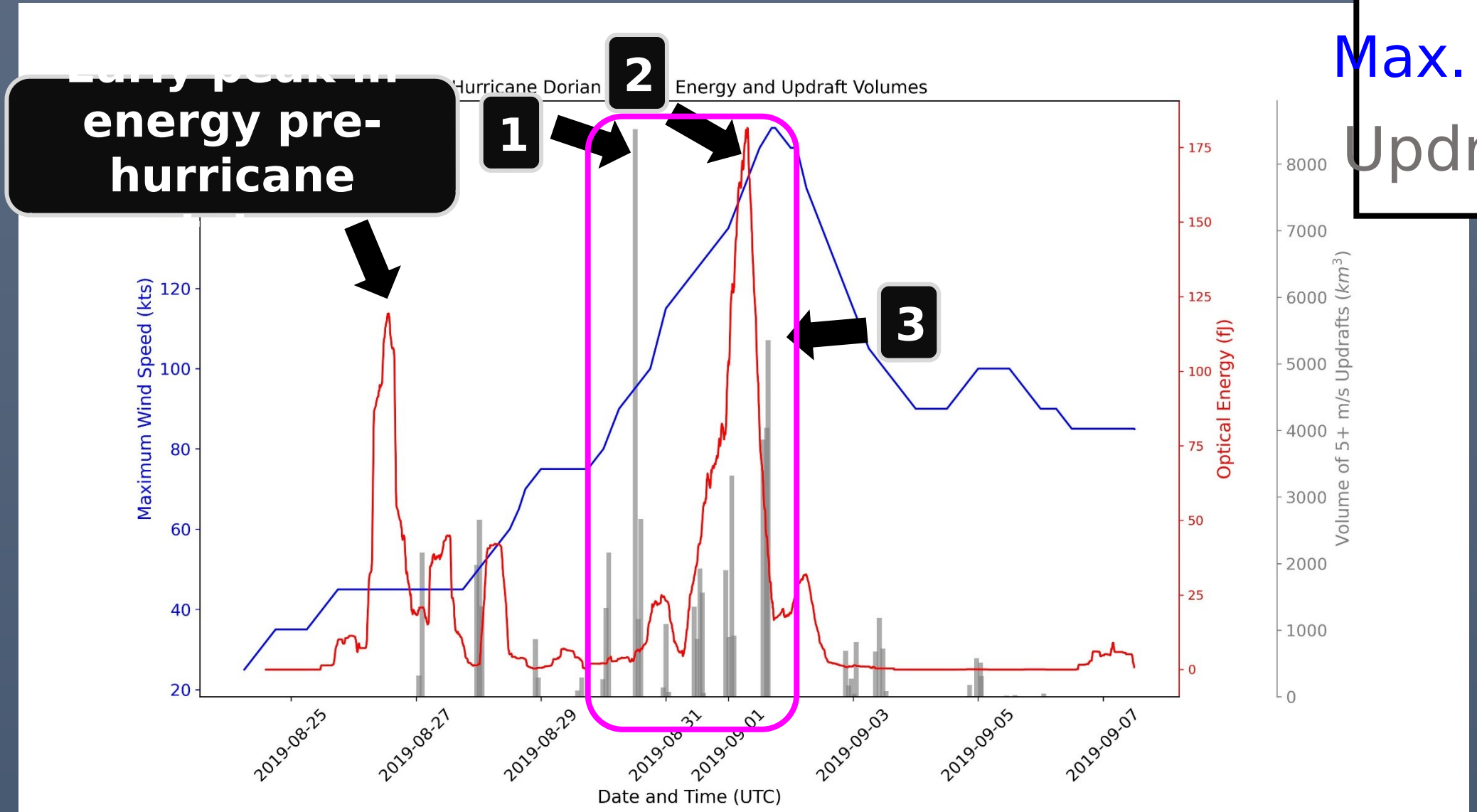

Hurricane Florence Optical Energy and Updraft Volumes
Maximum Wind Speed (kts)
120
100
80
60
40
Optical
40
20
0
Volume of 5+ m
800
600
400
200
0
09-08 00
09-08 12
09-09 00
09-09 12
09-10 00
09-10 12
09-11 00
Date and Time (UTC)

Results – Dorian Optical Energy

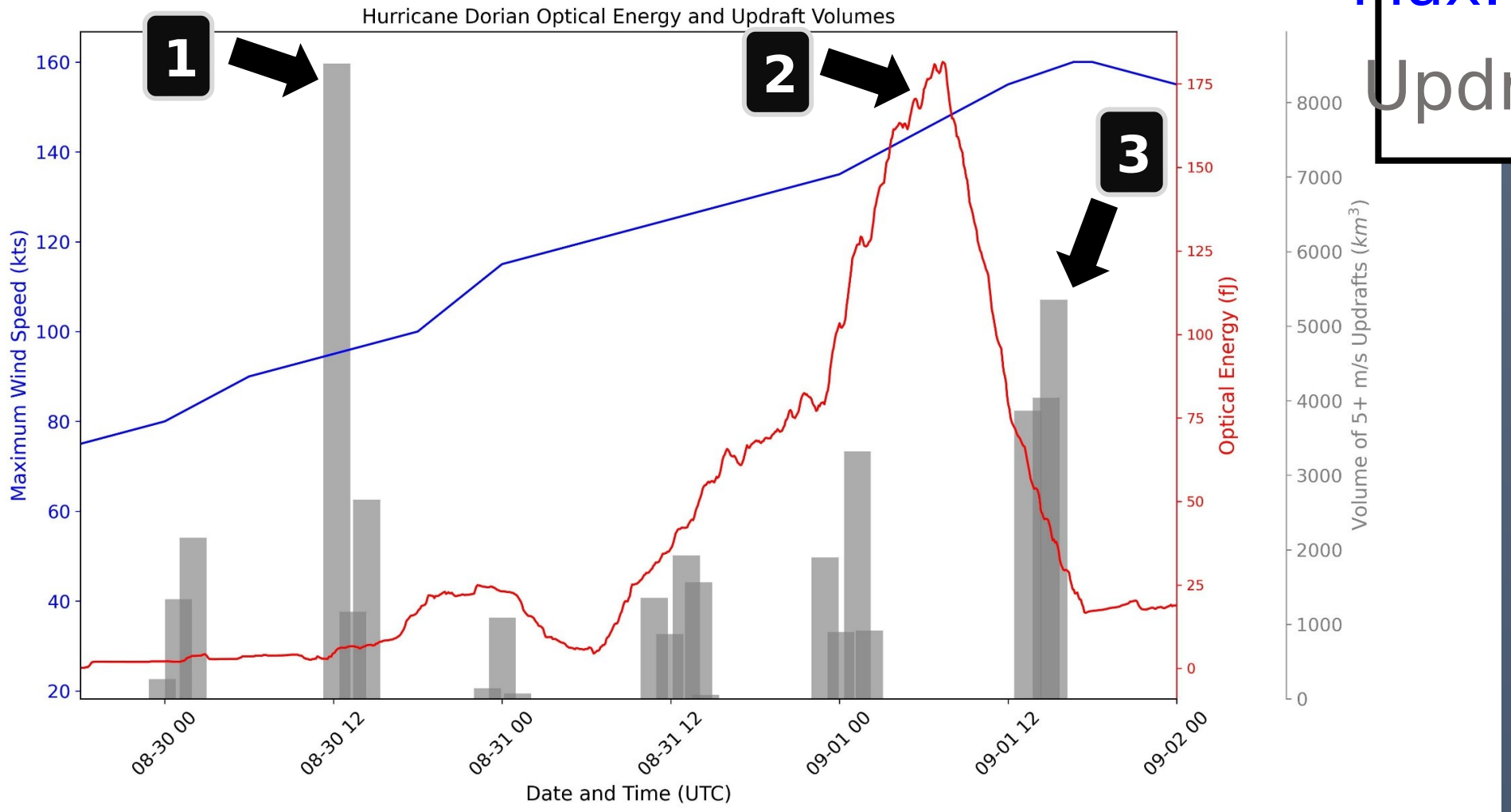
Optical Energy

Max. Wind Speed

Updraft Volume



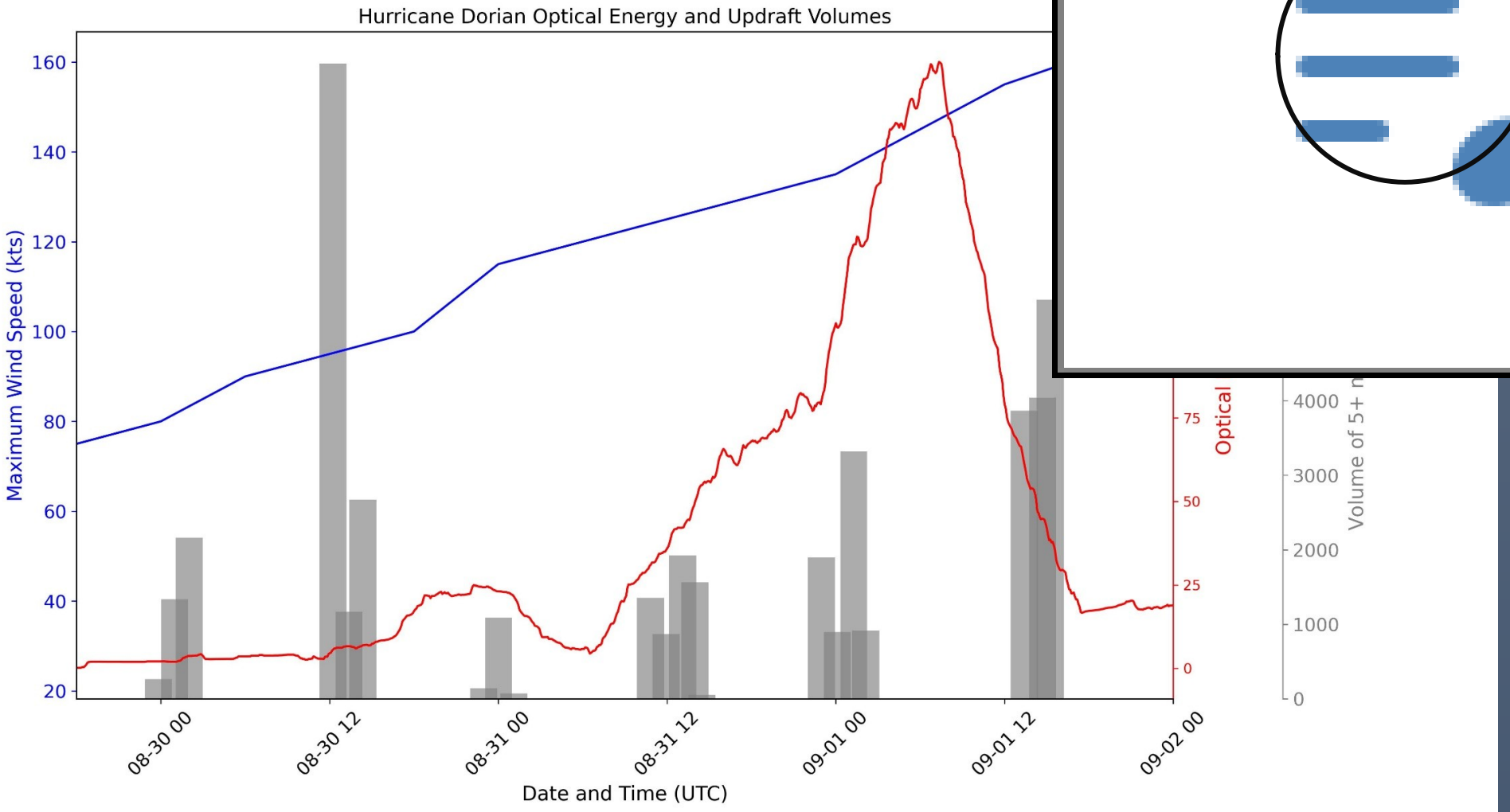
Results – Dorian Optical Energy



Optical Energy

Max. Wind Speed

Updraft Volume


Hurricane Dorian Optical Energy and Updraft Volumes
Maximum Wind Speed (kts)
160
140
120
100
80
60
40
20
Optical
75
50
25
0
Volume of 5+ m
4000
3000
2000
1000
0
08-30 00
08-30 12
08-31 00
08-31 12
09-01 00
09-01 12
09-02 00
Date and Time (UTC)

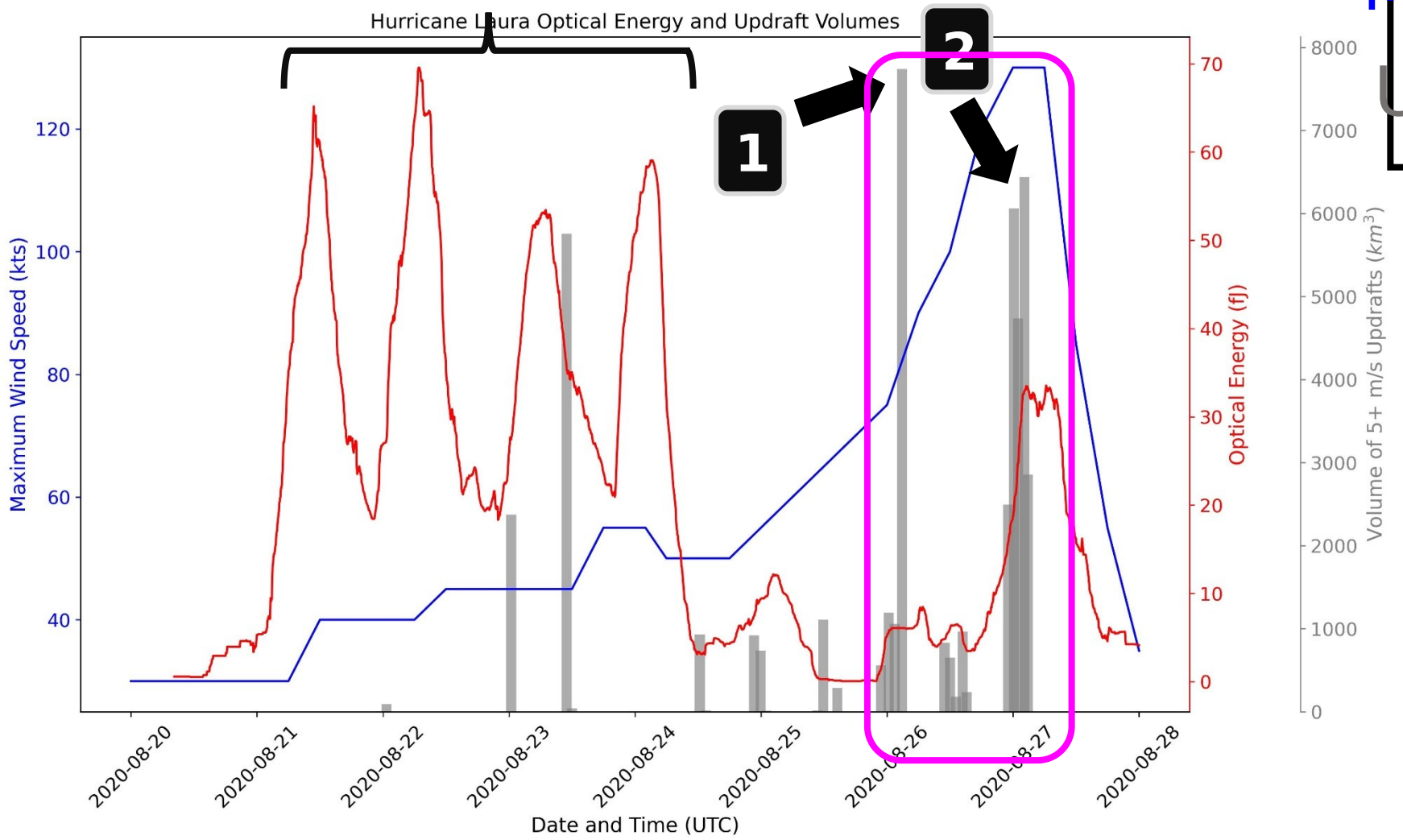
Results – Laura Optical Energy

Early peaks in energy pre-hurricane status

Optical Energy

Max. Wind Speed

Updraft Volume

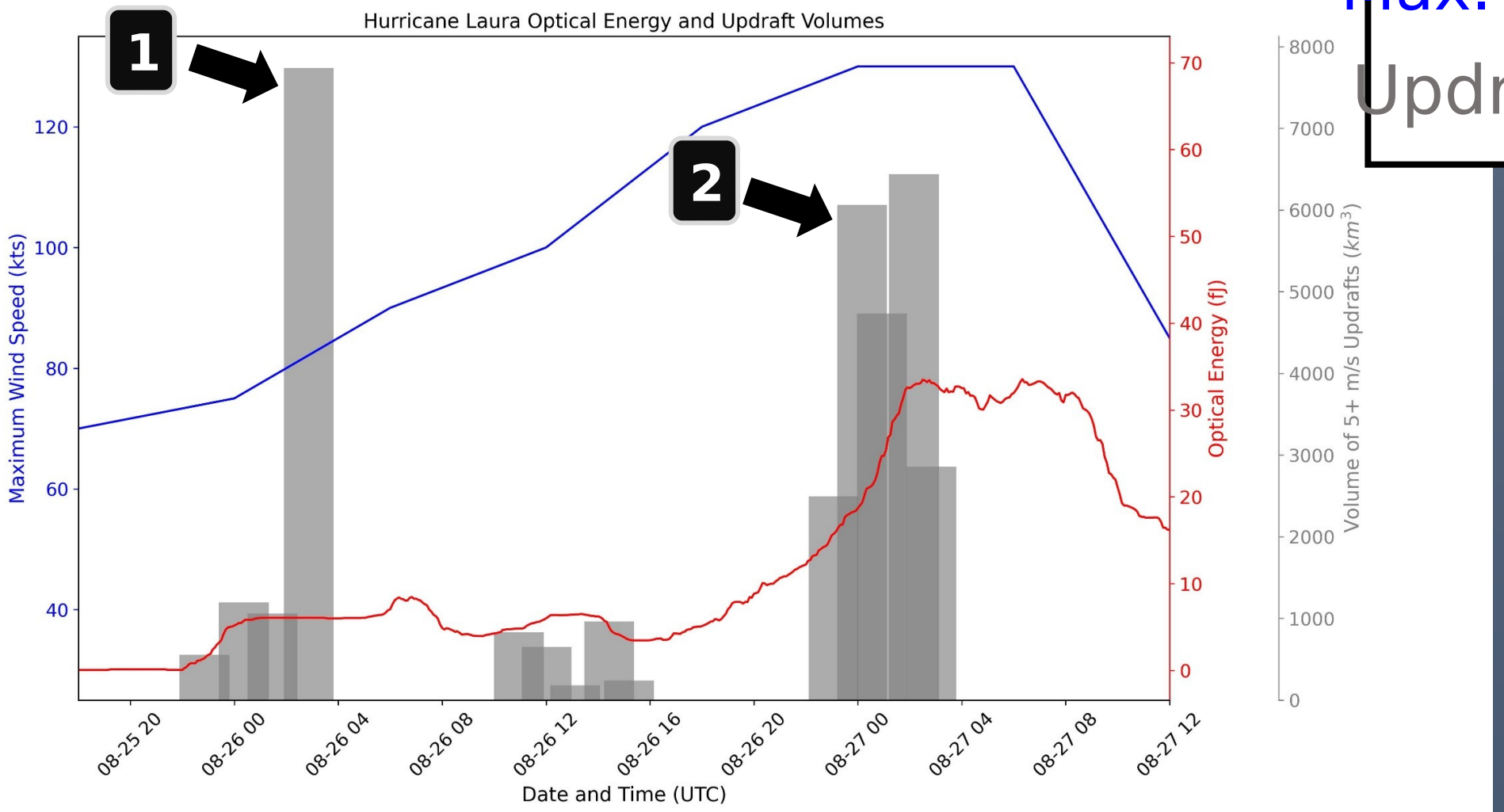


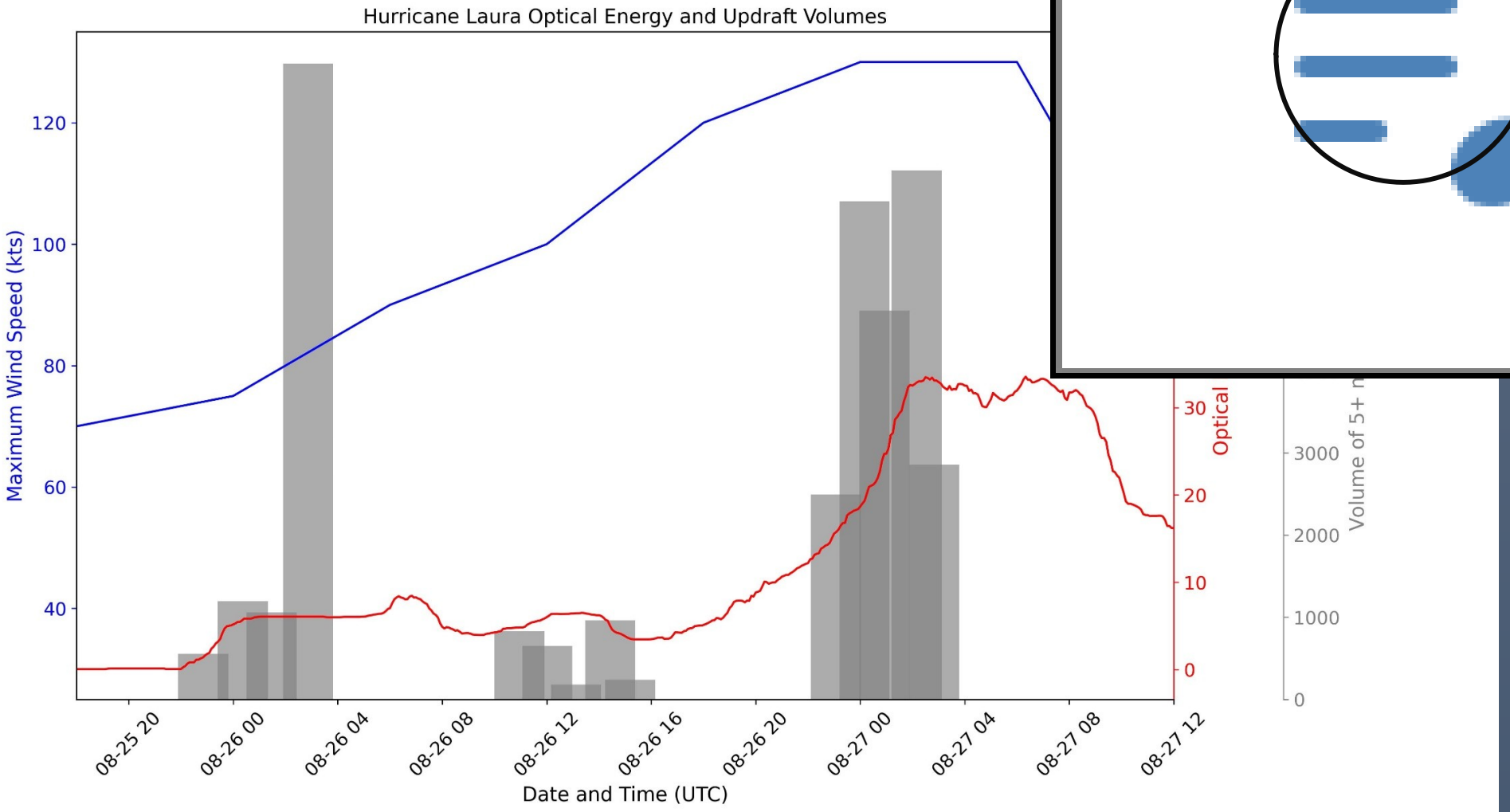
Results – Laura Optical Energy

Optical Energy

Max. Wind Speed

Updraft Volume




Hurricane Laura Optical Energy and Updraft Volumes
Maximum Wind Speed (kts)
120
100
80
60
40
Optical
30
20
10
0
Volume of 5+ m
3000
2000
1000
0
08-25 20
08-26 00
08-26 04
08-26 08
08-26 12
08-26 16
08-26 20
08-27 00
08-27 04
08-27 08
08-27 12
Date and Time (UTC)

Conclusions

- Optical energy often increases just after peaks in updraft volume in these storms
  - This may signal that larger updraft volumes allow for more energetic flashes

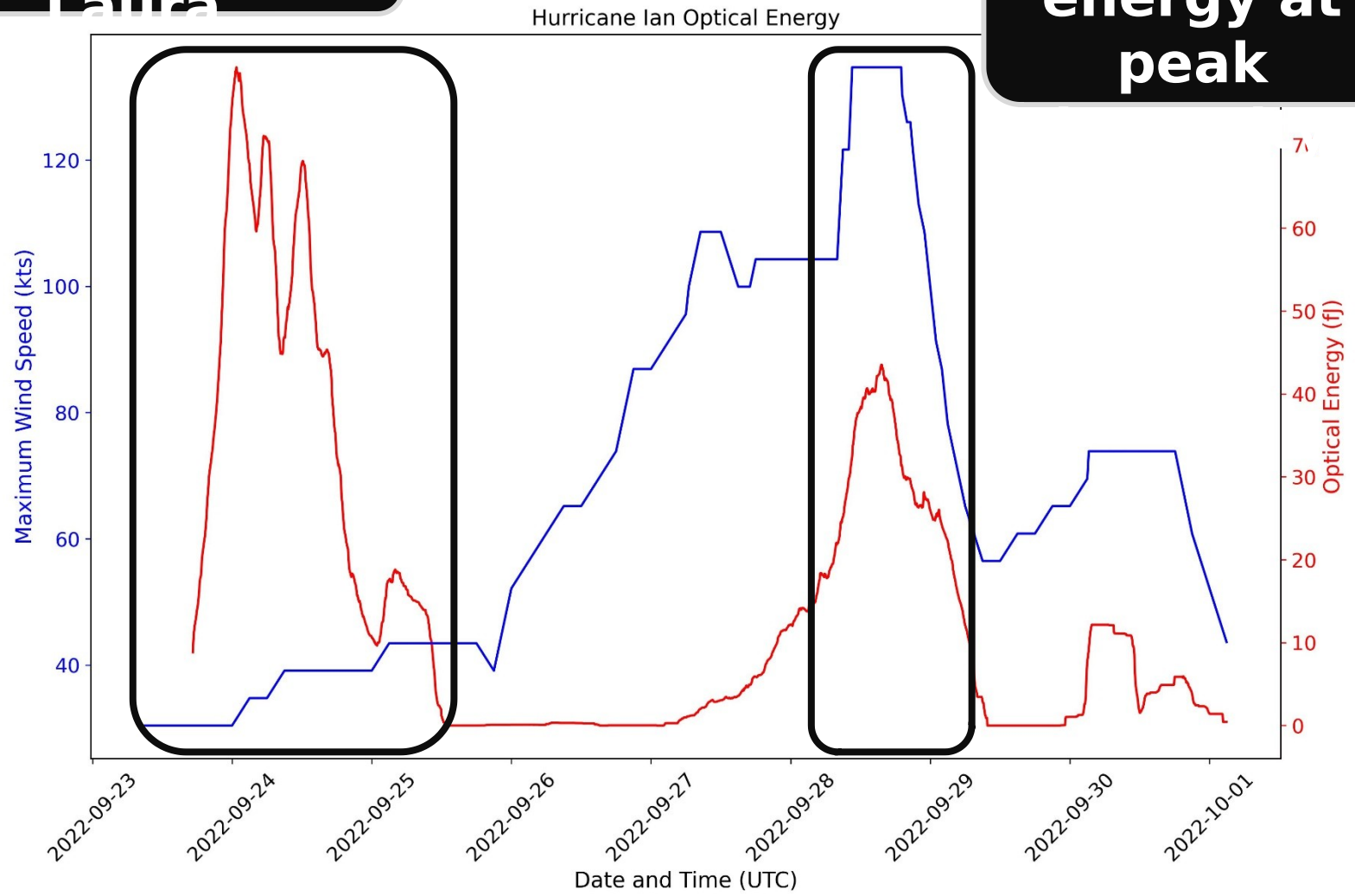
Ongoing Work

- Statistical analysis of these cases
- Adding Hurricane Ian:

Hurricane Ian Optical Energy

Early peaks in energy like Laura

Peak in optical energy at peak



Optical Energy

Max. Wind Speed

Updraft Volume

Data Sources

- GOES-16 Geostationary Lightning Mapper
- TC-RADAR Database[4]
- NHC Best Track

Contact and Supplemental Info

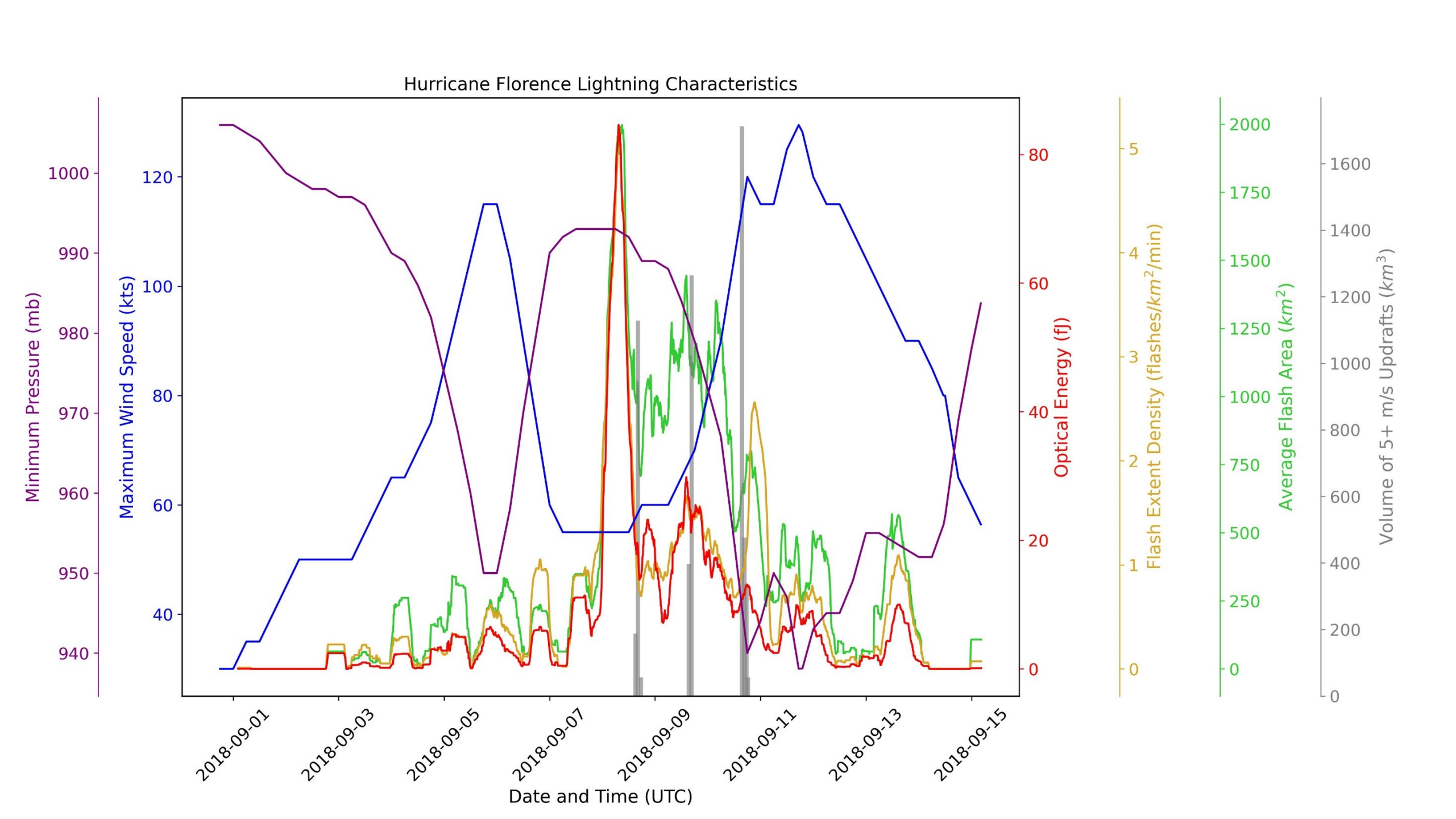
- Please feel free to contact me if you have any questions, comments, or suggestions:
  - krm0024@uah.edu
  - Kiahna.r.Mollette@nasa.gov

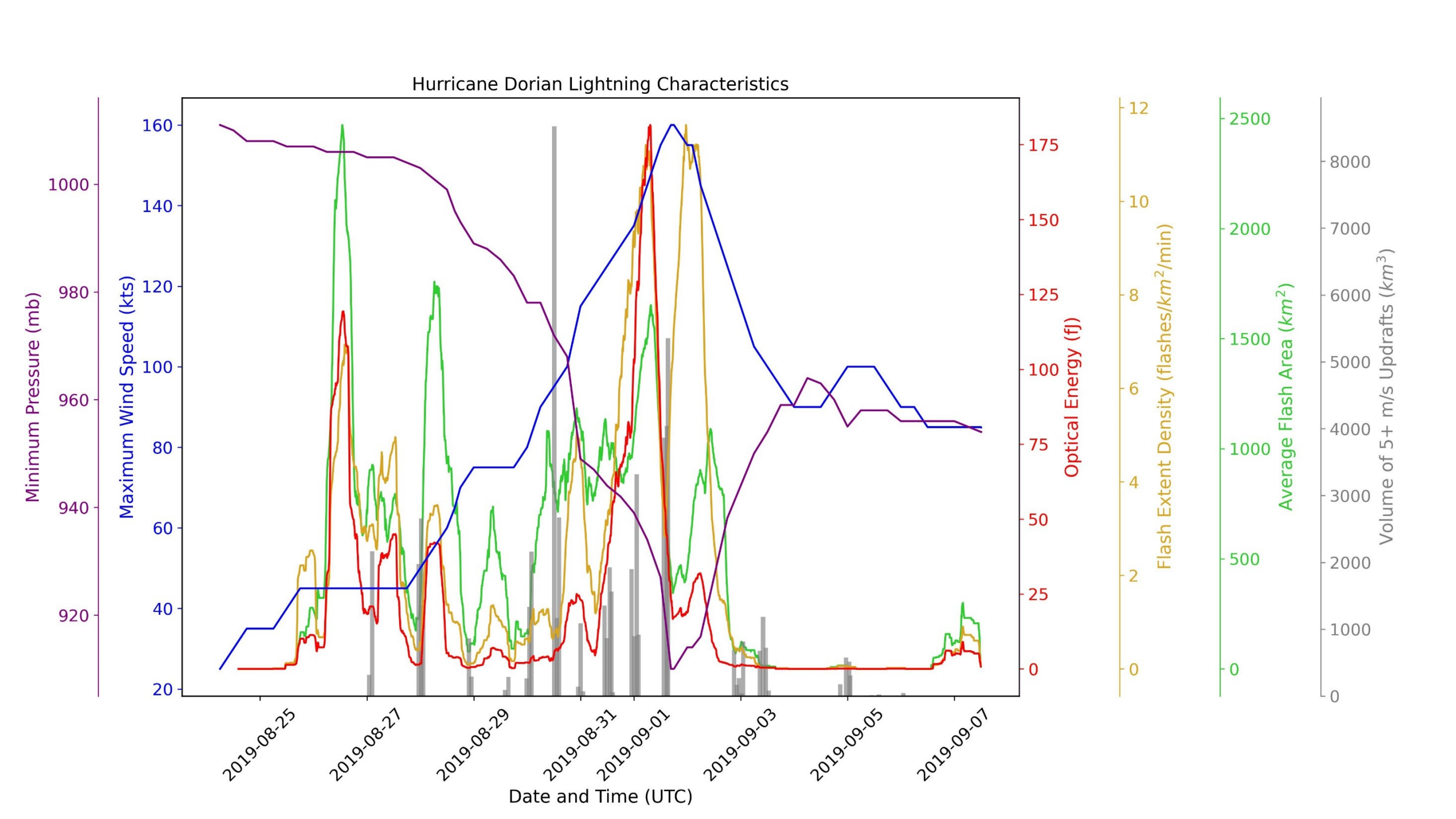
- Thank you for your time!

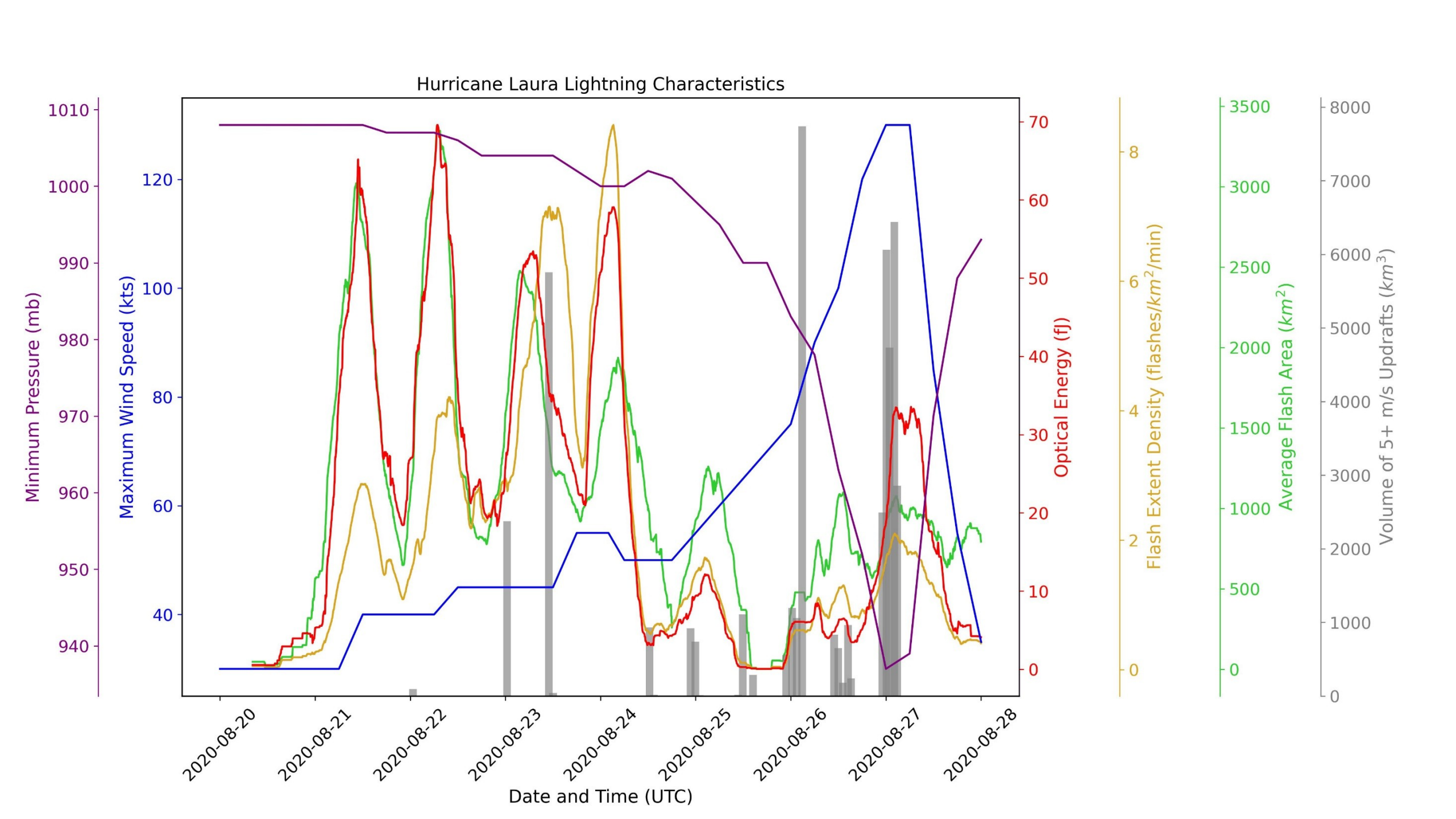
Scan with your phone camera for more information about these hurricanes and GLM and for easier access to my contact information!

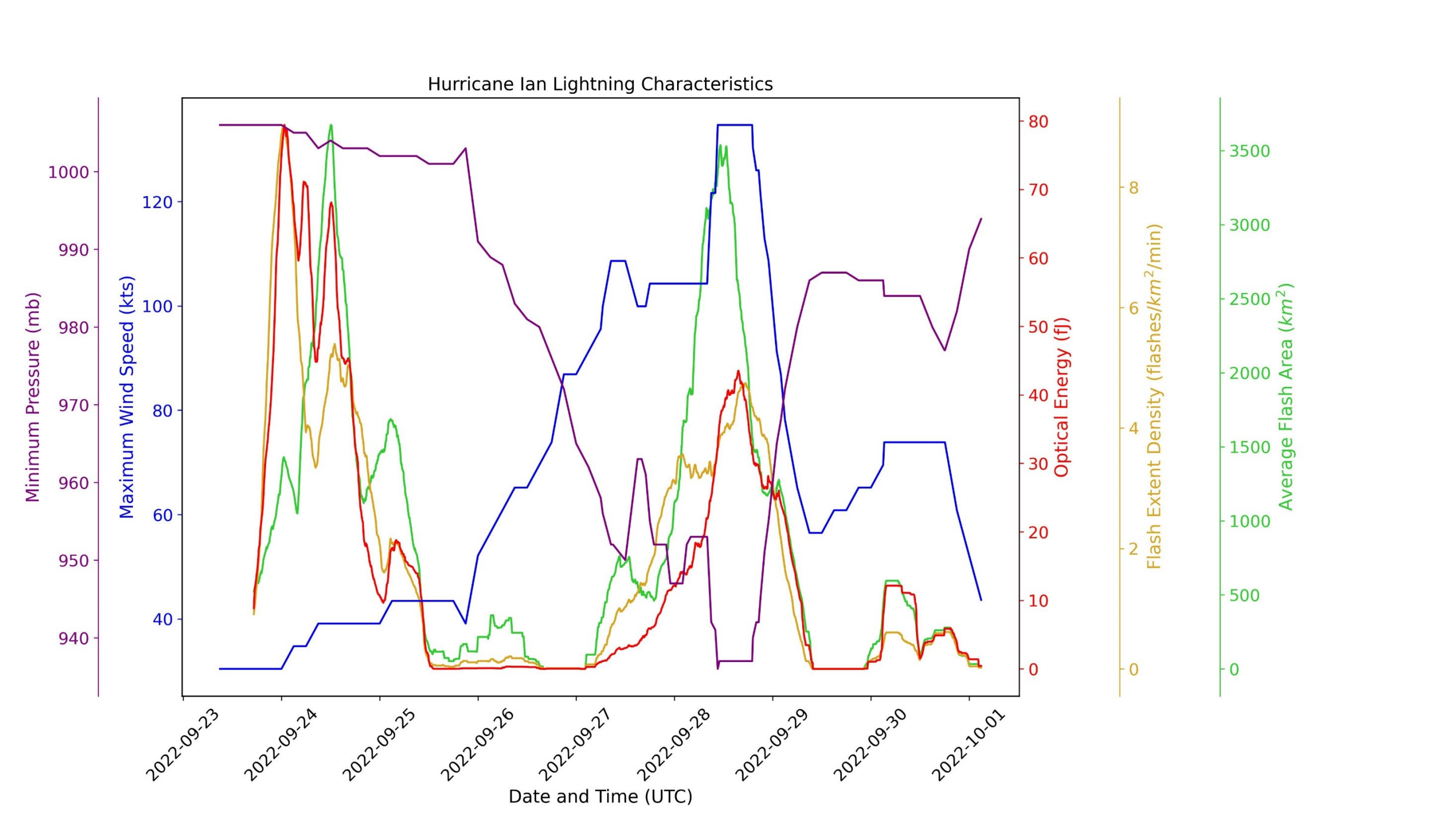
References

1. Stern, D. P., Bryan, G. H., & Aberson, S. D. (2016). Extreme Low-Level Updrafts and Wind Speeds Measured by Dropsondes in Tropical Cyclones, Monthly Weather Review, 144(6), 2177-2204. https://journals.ametsoc.org/view/journals/mwre/144/6/mwr-d-15-0313.1.xml
2. Fierro, A. O., & Reisner, J. M. (2011). High-Resolution Simulation of the Electrification and Lightning of Hurricane Rita during the Period of Rapid Intensification, Journal of the Atmospheric Sciences, 68(3), 477-494. https://journals.ametsoc.org/view/journals/atsc/68/3/2010jas3659.1.xml
3. Rogers, R. (2010). Convective-Scale Structure and Evolution during a High-Resolution Simulation of Tropical Cyclone Rapid Intensification, Journal of the Atmospheric Sciences, 67(1), 44-70. https://journals.ametsoc.org/view/journals/atsc/67/1/2009jas3122.1.xml
4. Fischer, M. S., Reasor, P. D., Rogers, R. F., & Gamache, J. F. (2022). An Analysis of Tropical Cyclone Vortex and Convective Characteristics in Relation to Storm Intensity Using a Novel Airborne Doppler Radar Database, Monthly Weather Review, 150(9), 2255-2278. https://journals.ametsoc.org/view/journals/mwre/150/9/MWR-D-21-0223.1.xml


Hurricane Florence Lightning Characteristics
Minimum Pressure (mb)
Maximum Wind Speed (kts)
Optical Energy (fJ)
Flash Extent Density (flashes/km^2/min)
Average Flash Area (km^2)
Volume of 5+ m/s Updrafts (km^3)
Date and Time (UTC)
2018-09-01
2018-09-03
2018-09-05
2018-09-07
2018-09-09
2018-09-11
2018-09-13
2018-09-15


Hurricane Dorian Lightning Characteristics
Minimum Pressure (mb)
Maximum Wind Speed (kts)
Optical Energy (fJ)
Flash Extent Density (flashes/km^2/min)
Average Flash Area (km^2)
Volume of 5+ m/s Updrafts (km^3)
Date and Time (UTC)
2019-08-25
2019-08-27
2019-08-29
2019-08-31
2019-09-01
2019-09-03
2019-09-05
2019-09-07


Hurricane Laura Lightning Characteristics
Minimum Pressure (mb)
Maximum Wind Speed (kts)
Optical Energy (fJ)
Flash Extent Density (flashes/km^2/min)
Average Flash Area (km^2)
Volume of 5+ m/s Updrafts (km^3)
Date and Time (UTC)
2020-08-20
2020-08-21
2020-08-22
2020-08-23
2020-08-24
2020-08-25
2020-08-26
2020-08-27
2020-08-28


Hurricane Ian Lightning Characteristics
Minimum Pressure (mb)
Maximum Wind Speed (kts)
Optical Energy (fJ)
Flash Extent Density (flashes/km^2/min)
Average Flash Area (km^2)
Date and Time (UTC)
2022-09-23
2022-09-24
2022-09-25
2022-09-26
2022-09-27
2022-09-28
2022-09-29
2022-09-30
2022-10-01